

Biometrics and sex identification of the Rose-Coloured Starling *Sturnus roseus*

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Biometric and plumage data on breeding Rose-coloured Starlings *Sturnus roseus* showed that the species is partially sexually dimorphic in size and plumage colour. Both sexes develop a brood patch, although it is most frequently found in females. Although males are generally more intensely coloured than females, there is much age-related overlap in colouration which makes sexing difficult. A discriminant equation based on wing and tarsus lengths was produced to provide an additional tool for sex classification.

It is not always possible to differentiate male and female Rose-coloured Starlings *Sturnus roseus* on the basis of their plumage features. Typical breeding adult males have pink upper and underparts, a long and glossy black crest, black throat, nape, undertail coverts and dark brown/black axillaries. Typical adult females also have pink upper and underparts, but usually not as brilliant and pure-coloured as those of males. Females also have a short crest, brown throat, nape and undertail coverts, and light brown axillaries (Svensson 1992, Cramp & Perrins 1994). Juveniles of both sexes have a uniformly grey-brown plumage. Despite these differences between typical birds, there is a high degree of variation between individuals in plumage colour, with many showing intermediate male and female characteristics.

Both adult and juvenile Rose-coloured Starlings perform a complete annual moult after the breeding season (Svensson 1992, Cramp & Perrins 1994), which could conceal age-related differences. However, the few accounts on moult and ageing of this species (Roberts 1982, van den Berg 1982, Svensson 1992, Cramp & Perrins 1994) report that at least the first post-juvenile plumage is duller and browner than the older adult plumage, though with great variation between individuals, which increases the possibility of confusion between sexes when the age of birds is not known precisely.

This paper summarises data collected at a breeding colony in North Dobroudja, Romania, and investigates the performance of a sex-discriminant function based on biometrics. Unlike the assessment of plumage colour, which may vary among different ringers according to their familiarity with a given species, measurements can

be of great help in the case of birds which are monomorphic or partly dimorphic in their plumage features but whose measurements do not completely overlap (see eg Green & Theobald 1989, Winker *et al* 1994, Weicker & Winker 2002). The use of measurements, moreover, does not require experience of birds' appearance. In the case of the Rose-coloured Starling, which is rarely caught throughout most of its Eurasian range, the use of morphometric criteria may therefore be particularly important.

METHODS

Birds were caught with mist nets on 16 and 17 July 2003, along the edge of a quarry mine near the city of Tulcea, Romania (45° 10'N 28° 49'E). The site has a breeding colony of approximately 3,800 pairs (Kiss *et al* in press). When trapping took place, some juveniles had already fledged, but most of them were still attended by adults in the nest. Wing length, tarsus length (both to the nearest mm) and mass (to the nearest 0.1 g) were measured by one of the authors (MZ), before the birds were ringed and released. We did not measure the length of elongated crown feathers (Svensson 1992), but used the colour of upper and underparts, and in particular of the amount and brightness of pink feathers, and the colour and brilliance of throat, nape and crown to separate the sexes. Birds with plumage features in full agreement with Svensson (1992) and Cramp & Perrins (1994), ie fitting the typical description of adult males and females, were sexed accordingly. Birds with intermediate plumages or showing a combination of

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male and female characters were sexed as “probable male” or “probable female”, according to the prevalence of male- or female-like features (Svensson 1992, Cramp & Perrins 1994); their biometrics were not used for the calculation of the discriminant function.

Wing and tarsus lengths of known males and females were used to produce a discriminant function for sex identification, using the unstandardised canonical discriminant function procedure of SPSS for Windows version 10. The ability of this function to identify males and females is indicated as the percentage of individuals correctly classified from the sample that generated the function. A jackknife approach was used to estimate how well the discriminant function performed (Sokal & Rohlf 1981). The discriminant function was then applied to birds with intermediate or contrasting plumage features, to test whether the result of biometric analysis agreed with their probable sex.

RESULTS

Plumage colour and biometrics

Sixty-eight adults (second year or older) and nine fledged juveniles were trapped; their biometrics are summarised in Table 1. Forty-one adults showed a clear combination of plumage characters which led them to be classified as males (N = 17) or females (N = 24). The sex ratio of this sample was not significantly different from 1:1 ($\chi^2 = 0.30$, $P = 0.584$). The other 27 adults showed a combination of male and female characteristics or intermediate features. Among them, 13 were sexed as probable males and 14 as probable females. Most adults (50 out of 68; 73%) had a brood patch, which was more frequently found in females (23 individuals out of 24, 96%) than males (5 individuals out of 17, 29%). With the exception of a single individual, all juveniles were finishing the growth of their primary feathers. Juveniles had lower body masses ($t_{6,2} = 3.79$, $P = 0.008$) and shorter tarsus lengths ($t_{75} = 2.18$, $P = 0.03$) than adults. Adult males were, on average, larger and heavier than adult females (Table 2).

Discriminant analysis

The analysis of wing and tarsus lengths of the 17 males and 24 females produced the following discriminant equation (Eq 1):

$$D = 0.740 \text{ wing} + 0.964 \text{ tarsus} - 124.235 \quad (\text{Eq 1})$$

which can be directly used for the classification of individual birds, since positive D scores indicate males and negative scores indicate females. This function correctly classified 95% of individuals from the sample of known-sex birds, with only two males being incorrectly assigned as female. Cross-validation with the jackknife method indicated a 93% overall success rate (88% of males and 96% of females correctly assigned). The discriminating power of wing length was higher than that of tarsus, the respective standardised canonical discriminant function coefficients being 0.880 and 0.524.

Wing and tarsus lengths of adults are plotted in Fig 1, with the discriminant function and its 0.05 and 0.95 probability contours of being male, calculated using the method of Green & Theobald (1989). This method allows the calculation of the individual probability that an unknown case is male using its canonical discriminant score (Eq 2),

$$P_{(\text{male})} = 1/(1 + e^{-S}) \quad (\text{Eq 2})$$

where e is the base of natural logarithms (2.7183) and S the canonical discriminant score, calculated as shown in Eq 3:

$$S = 0.326 \text{ wing} + 0.425 \text{ tarsus} - 54.623 \quad (\text{Eq 3})$$

The two birds sexed as males using plumage features and classified in the female group by the equation (Fig 1) have wings at the lowest edge of the male distribution. One of these birds died and could therefore be sexed as female by gonadal inspection, hence confirming the classification made with biometrics in spite of its male-like appearance. The gonadal

Table 1. Biometrics (mean \pm SD) of Rose-coloured Starlings caught during the ringing sessions.

	Wing (mm)	Tarsus (mm)	Body mass (g)
Adults (total sample)	127.0 \pm 3.4 (N = 68)	31.4 \pm 1.3 (N = 68)	77.3 \pm 6.9 (N = 62)
Adult males	129.7 \pm 3.0 (N = 17)	32.0 \pm 1.2 (N = 17)	83.9 \pm 5.7 (N = 15)
Adult females	124.5 \pm 2.5 (N = 24)	30.7 \pm 1.3 (N = 24)	72.7 \pm 4.7 (N = 23)
Juveniles	-	30.3 \pm 1.9 (N = 9)	52.1 \pm 17.4 (N = 7)
Comparison of adult males and females	$t_{39} = 6.09$, $P < 0.001$	$t_{39} = 3.41$, $P = 0.002$	$t_{36} = 6.60$, $P < 0.001$

Table 2. Classification, according to their discriminant function score, of adult Rose-coloured Starlings initially sexed as 'probable male' or 'probable female'.

Presumed sex	Sex according to discriminant function	
	Male	Female
Probable male	11	2
Probable female	6	8

inspection of a further dead bird from the reference group, which had been sexed as female and whose discriminant score was very close to 0 (Fig 1), again confirmed the sex attributed using plumage colour and biometrics.

Using the discriminant function on the 27 individuals which had been sexed as "probable male" or "probable female" at ringing, showed a 70% correspondence between sex suggested by plumage and that suggested from the biometrics (Table 2). The misclassification rate was lower among females, although differences with males remained just below statistical significance ($\chi^2_1 = 3.41$, $P = 0.06$).

DISCUSSION

In accordance with data reported by Cramp & Perrins (1994), both males and females can develop a brood patch, which in our sample was more frequently encountered among females. A recalculation of the frequency of incubation patches in males and females on the total sample resulting from the discriminant equation, shows that 50% of males ($N = 32$) had incubation patches compared to 94% of females ($N = 36$). The large prevalence of brood patches among females could indicate that only a small percentage of males contribute to the incubation of eggs. Alternatively, it might suggest that not all of the males caught at the colony were breeding, if we also assume that both sexes contribute in the same way to the care of their offspring (see Cramp & Perrins 1994 for contrasting results on this topic). Schenk (1934) reports that males outnumber females at breeding colonies. Even though our catching sample was not skewed towards males, evening movements of some hundreds of birds towards unknown roosts away from the colony site were observed during this study (M Marinov jnr and JB Kiss pers obs), suggesting that some individuals which were observed at the colony site during daytime may not breed.

The discriminant analysis highlights the fact that larger and heavier birds (males) are usually also the most colourful ones (Cramp & Perrins 1994). The

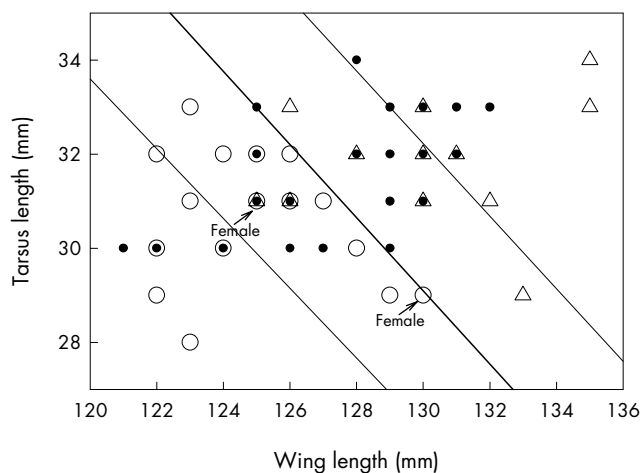


Figure 1. Sex distribution of wing and tarsus lengths of adult Rose-coloured Starlings, as sexed by means of plumage colour. Unsexed birds are shown as small filled circles, males as triangles and females as open circles. The lines represent the 0.05, 0.50 and 0.95 probability contours of being male (Green & Theobald 1989). Arrows indicate the measurements of the two birds sexed by dissection.

correspondence between plumage features and size of adults observed in the reference sample show that, within large samples, typical males can be reliably told apart from typical females by the examination of their plumage, with a rather low misclassification rate. However, a sizeable 40% of adults cannot be sexed in this way, and require morphometric features to be taken into account. Since the post-juvenile plumage of this species is duller than that of adults (van den Berg 1982, Svensson 1992, Cramp & Perrins 1994), the high percentage of males discriminated by the analysis among individuals initially classified as "probable females" shows that birds of different age cohorts co-exist within our sample. Such individuals, although wearing an immature plumage, should nonetheless be considered as true breeders, since this species is known to reach sexual maturity at one year (Dementiev & Gladkov 1954).

The finding of one female with a plumage as colourful as that of males, which had been correctly classified by the discriminant function, enforces the reliability of biometrics to separate the two sexes. A further individual sexed as male using plumage features, but classified among females by the discriminant function (Fig 1), might accordingly be another bright-coloured female. Biometric measurements should therefore always be taken into account, to increase the consistency of individual sexing, especially by ringers who are unfamiliar with this species.

With the results of this study it is possible to sex Rose-coloured Starlings using two standard biometric

measurements, either applying Equation 1 or Fig 1, or, as an alternative, individually calculating the exact probability of being male with Equation 2. The reduced size of the reference sample and the partial overlap of the measurements between the sexes caused the discriminant function to have a large confidence interval, so that only 15 females and 13 males (41% of the adult sample) may be sexed at $P < 0.05$. It has, nonetheless, shown that the combined use of plumage and biometrics may considerably increase the reliability of sexing. In many species, the variability of biometrics between different areas usually narrows the applicability of discriminant functions to a limited geographic range (Weicker & Winker 2002). The fairly restricted breeding distribution of the Rose-coloured Starling, stretching between East Europe and Central Asia, and the absence of any known geographical trend of body measurements, suggest that the results of this analysis may be useful throughout its range. However, studies to test the validity of these measurements on samples taken from other populations or in different seasons should always consider that other potential sources of error may exist, due to, for example, inter-observer differences in measurement techniques, feather abrasion and age changes of wing or tarsus measurements (Mueller 1990, Hamer & Furness 1991, Gosler *et al* 1995, Sweeney & Tatner 1996).

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REFERENCES

- Cramp, S. & Perrins, C.M.** (eds) (1994) *The Birds of the Western Palearctic*. Vol VIII. Oxford University Press, Oxford.
- Dementiev, G.P. & Gladkov, N.A.** (eds) (1954) [*Birds of the Soviet Union*. Vol V]. Sovetskaya Nauka, Moskva.
- Gosler, A.G., Greenwood, J.J.D., Baker, J.K. & King, J.R.** (1995) A comparison of wing length and primary length as size measurements for small passerines: a report to the British Ringing Committee. *Ringing & Migration* **16**, 65-78.
- Green, P.T. & Theobald, C.M.** (1989) Sexing birds by discriminant analysis: further considerations. *Ibis* **131**, 442-447.
- Hamer, K.C. & Furness, R.W.** (1991) Sexing Great Skuas *Catharacta skua* by discriminant analysis using external measurements. *Ringing & Migration* **12**, 16-22.
- Kiss, J.B., Zenatello, M., Szabo, L. & Marinov, M. jr.** (in press) *Data on breeding ecology of the Rose-coloured Starling *Sturnus roseus* (L) in Dobrudja (Romania) in 2002-2003*. Proceedings XII Annual Scientific Symposium on Deltas and Wetlands, Tulcea 17-21 September 2003.
- Mueller, H.C.** (1990) Can Saw-whet Owls be sexed by external measurements? *Journal of Field Ornithology* **61**, 339-346.
- Roberts, P.** (1982) Post-juvenile moult of Rose-coloured Starling. *British Birds* **75**, 38-40.
- Schenk, J.** (1934) Die brutinvasion des Rosenstares in Ungarn in den Jahren 1932 und 1933. *Aquila* **38-41**, 121-153.
- Sokal, R.R. & Rohlf, F.J.** (1981) *Biometry*. Freeman & Co, New York.
- Svensson, L.** (1992) *Identification Guide to European Passerines*. 4th edn. Svensson, Stockholm.
- Sweeney, J.J. & Tatner, P.** (1996) Sexing Wrens *Troglodytes troglodytes indigenus* using morphological measurements and discriminant analysis. *Bird Study* **43**, 342-350.
- van den Berg, A.B.** (1982) Moults and basic plumages of Rose-coloured Starling. *Dutch Birding* **4**, 136-139.
- Weicker, J.J. & Winker, K.** (2002) Sexual dimorphism in the birds from southern Veracruz, Mexico, and other localities. III Wilson's Warbler (*Wilsonia pusilla*). *Journal of Field Ornithology* **73**, 62-69.
- Winker, K., Voelker, G.A. & Klicka, J.T.** (1994) A morphometric examination of sexual dimorphism in the *Hylophilus*, *Xenops*, and an *Automolus* from Southern Veracruz, Mexico. *Journal of Field Ornithology* **65**, 307-323.

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